

Machine learning and artificial intelligence as educational games

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ABSTRACT

Digital games are establishing themselves as a new paradigm in teaching. Everyone can play digital games, they're economical, and they're a terrific way to learn. Digital games that encourage computational thinking and programming have recently attracted more attention in pre-college (K-12) educational institutions. A growing number of students have been drawn to the subjects of In recent years, there has been an increase in artificial intelligence (AI) and machine learning (ML). Researchers in teaching and learning are interested in the integration of AI/ML with digital gaming, however there hasn't been a literature review in this field. This paper aims to summarize the most recent findings on instructional video games for AI and ML. A qualitative content analysis was conducted using the relevant essays and games that were selected following a comprehensive search. Using this summary as a base, we present a list of research publications and games that are relevant. illustrating the unique opportunities that diverse games offer to teach various AI and ML techniques and topics.

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1. INTRODUCTION

In recent years, the study of computer science (CS) and information technology (IT) has seen a rise in popularity of digital games. The usage of digital games as a popular method has been employed by several projects to enhance CS education. Programs exist that encourage playing games with the students with responsibilities and issues that need to be resolved for proceed in K-12 schools. Alternately, kids might be urged utilizing block-based and graphic programming platforms to create video games.

like Alice or Scratch. However, rather than focusing on more complex Game-based learning mostly focuses on CS topics projects emphasize the aesthetic and art of programming.

Students generally have positive feelings towards projects that involve games, game-based learning, and other types of informal learning. Additionally, these strategies benefit pupils' learning and motivation. shows that, contrary to the norm, students surpass project requirements on a regular basis in his game-based course. Therefore, It indicates that the game-based approach offer inherent benefits in the CS education literature, which supports the discipline's extensive use of such practices.

The obvious relationship between gaming and artificial intelligence (AI) techniques is what inspired us to do this research. With considerable success, the emphasis on introducing game components the field of CS education particularly centered on specialized both on basic courses and in game design and development courses (such as CS0, CS1, and CS2). In addition, AI research has long found games and puzzles to be intriguing problem fields. In addition, For a long time, games were seen as the ideal testing ground for AI techniques, therefore the fusion of game mechanics and the AI domain is significant and beneficial that pupils foster an interest in and competency in the increasingly vital topic of AI.

The goal of the literature review in this chapter is to present an overview of current studies on games that may be used to improve artificial intelligence and machine learning (ML) training while taking into consideration the benefits and challenges mentioned above. Artificial intelligence (AI) is expected to spread and play a bigger role in education. AI is expected to spread and become more prominent in the educational sector. In a recent working paper, the United Nations Educational, Scientific and Cultural Organization (UNESCO) examines the design of learning spaces and digital learning systems that incorporate AI together with the advantages and disadvantages of AI for all parties involved the participation of peers in education, educators, administration staff, and policymakers. The importance of include Instead of merely considering beneficiaries or users during the early design stages, it is important to include all stakeholders. suggested, and social and ethical aspects are underlined. This chapter is positioned in this area, the supply of tools to enable instructors and students to grasp and participate actively in the development of AI and machine learning systems, It provides an overall assessment of how various gaming there have been elements employed to advance AI and ML which was before education. There has been enough research done to do a review and offer insights, even if the convergence of gaming elements with AI/ML which was before educational is still in its early phases.

2. Related Work

In recent years, a growing number of academics and students have been interested in the quickly developing disciplines of artificial intelligence and machine learning. The promotion of AI education in K–12 classrooms is being promoted in the US, China, and many other countries in response to this demand. Additionally, in recent Years have passed since the development of new curriculum and internet resources with a focus professional development for K–12 teachers and pre-college students understand the principles of AI. The creation of national standards to promote AI education among K–12 students was a joint project between the Association for the Advancement of Artificial Intelligence (AAAI) and the Computer Science Teachers Association (CSTA), which was unveiled in 2018. To specify what kids should know and be able to accomplish using AI, organizations like The working groups for AI for K–12 (AI4K12) and AI4All (<http://ai-4-all.org>) were created. Additionally, national standards will be created, and materials (including films, software demos, and activity descriptions) will be gathered for AI instruction in the US.

Recently, a number of hardware and software solutions young students to work with AI and ML through the creation of various tools. For instance, the Cognimates website (<http://cognimates.me>) offers a selection accessible with the use of Scratch extensions, APIs for voice creation, speech recognition, text classification, object detection, and robot control (APIs). This paper created eCraft2Learn (<https://ecraft2learn.github.io/ai>). Classifiers may be trained by students utilizing through the ML for Kids website (<https://machinelearningforkids.co.uk>), users may access online applications or Scratch extensions. In order to help students learn about the fundamentals of artificial intelligence, Google has also produced a variety of software tools. For instance, It has created an idea for

a "online AI experiment" (<https://experiments.withgoogle.com/collection/ai>), It allows elementary school pupils to train visual classifiers (i.e., Teachable Machine) alternatively see how a neural network tries to deduce what the person is sketching (i.e., QuickDraw). Another illustration is the "AI and You" kits from Google, which offer inexpensive voice and picture recognition powered by Raspberry Pi Zero (using a neural network classifier). Another website that uses an interactive graphical interface to let TensorFlow Playground (<https://playground.tensorflow.org>), a website for K–12 kids, teaches them about neural networks and back-propagation learning. As a response, throughout the previous few years, a number of efforts have produced software and hardware solutions to help K–12 students interact with AI and ML.

Despite the tremendous advancements in AI/ML education, newcomers still find it challenging to grasp concepts like decision trees, game theory, machine learning, and other basic concepts. The 2014 EAAI Conference on Educational Advances in Artificial Intelligence attendees reported that 68% of their AI courses include a discussion of games and riddles. This research also demonstrates how teachers might provide subjects for further inquiry including search, iterative string replacement, planning, ML, and other related topics by utilizing games and puzzles to introduce agent-based models. It may be argued that this is why video Games have been around for a while considered an ideal environment for testing AI techniques.

Games (and game-based curricula) are a popular medium for CS and IT education and learning. Games have been used to enhance numerous elements of CS and IT education, such as the lack of diversity in STEM fields, including CS, at both the university and K-12 levels. Games have also been utilized to increase student motivation and engagement. This paper created an engaging game of military strategy enabling the insertion of AI modules. Their findings show that using examples and projects based on this game makes AI considerably more intriguing and accessible to students. Aside from initiatives to create unique CS teaching and learning in formal education may be improved by game-based curriculum, numerous approaches to involving younger youngsters are produced in casual settings such as after-school activities, summer camps, and classroom visits.

In addition to the benefits of engagement, competitiveness, and teamwork, games increase student attention. Games can definitely be useful as content for AI and ML. In addition, this paper showed the effectiveness of games in supporting AI/ML teaching by using a straightforward game to instruct students on the importance of world views that are internally represented, NLP, the creation of plans, ML, and look-ahead search. The game was extensively enhanced and changed by their students to accommodate various issues.

We believe that introducing students to cutting-edge game-playing algorithms, ideas, and techniques—like reinforcement learning, neural networks, and game tree-based search—can considerably advance the field of machine learning and artificial intelligence teaching. Pre-college students could be successfully introduced to such ideas using this strategy. In the literature, there are a number of research that link AI/ML with video gaming as the foundation for a separate a module or a course inside a larger course. In this article, we offer an overview of the software programs and games that can be utilized to enhance AI and ML pre-college instruction. Other academics and professionals can use this collection as a starting point to put the games and software provided to use in their own research, experiments, comparisons, and adaptations to fit the needs of their students.

3. METHOD

As far as we are aware, no prior research has attempted to develop a list of video games and software programs that may be used to improve pre-college training in AI and ML. The goal is to compile and enumerate the various games and software tools in this chapter available. Various stakeholders can benefit from and be directed by the thorough analysis presented in this chapter in the direction of finding and putting the games that will best serve their requirements into practice.

Determining precise criteria is crucial because the selection phase affects the work's overall validity. Games with an AI/ML education theme were allowed to be included. We looked through a variety of libraries, search engines (like Google), and academic journals to

identify those games (Google Search, ACM Digital Library, IEEE Xplore, Science Direct, and Google Scholar are a few examples.3cr).

The hunt phrase utilized includes two key terms for both the medium ("Game-Based Learning," "Games for Learning") and the topic ("AI Education," "ML Education," and "CS Education"). Six separate search strings emerged from the combination. The authors chose to focus the search by combining the word "CS Education" with either the term "AI" or "ML" because of the large number of unrelated publications (i.e., false positives) that were retrieved using that search string.

4. RESULTS AND DISCUSSION

Finally, after employing the aforementioned search approach, we evaluated the results and discovered 17 games/projects. After that, we went over the projects and games mentioned again and outlined their key components and focus (Table 1). These summaries helped us to focus on the core ideas and primary goals of the projects and games and how they related to AI/ML ideas.

Table 1. Overview of online games for machine learning furthermore, artificial intelligence (AI) (ML)

Game's Title Brief Description Reference	Game's Title Brief Description Reference	Game's Title Brief Description Reference
Bug Head	Children may explore in conjunction with the brain's neurons and nodes in the game Bug Brain. To assist a ladybug live and find food, they construct a brain for it. Bug Brain offers realistic images, difficult a chance to learn about neural networks, riddles, and but is not primarily designed to teach AI and ML (free).	http://www.biologic.com.au/bugbrain/
Machine for Human Resources	Play the puzzle game Human Resource Machine. Programming challenges are presented to players. Automaton and optimization are introduced as concepts with a bearing on AI. In order to advance through each level, players must automate tasks by programming office workers (purchase required).	http://tomorrowcorporation.com/humanresourcesmachine
7 billion people	Players must program several agents to solve tasks in this sequel to the "Human Resource Machine" game, which was created by the same firm (workers). There is exploration of ideas like parallel processing, debugging, and optimization (purchase required).	https://tomorrowcorporation.com/7billionhumans
Machine Learning for Kids	By offering practical opportunities for ML system training and creation, Machine Learning for Kids teaches the technology to young learners. It offers a user-friendly controlled setting for developing ML models that can detect text, numbers, photos, or noises. Scratch and App Inventor, instructional coding platforms, now include models thanks to Machine Learning for Kids, which also enables kids to construct projects and play games using the ML models they train (free).	https://machinelearningforkids.co.uk/
Tools for Education using AI Machine Learning	The platform, which is still in development, provides tools for instructing students in fundamental machine learning principles. As a tool for teaching kids how to code, it integrates several Scratch extensions, including a Extension of the chatbot, automation of the house, picture recognition, categorization, and training the computer to play the game Flappy Bird, along with lesson plans and resources for teachers (free registration required).	https://www.ai4children.org

While True: Learn()	The purpose of this game is to introduce players to the ideas and procedures of machine learning. Players assume the character of an ML expert who employs visual programming to finish assignments for clients. It covers components like neural networks, real machine learning algorithms, and issues like self-driving vehicles that are connected to ML (purchase required).	https://luden.io/wtl/
ViPER	ViPER attempts to instruct middle-school pupils in ML ideas. Players get insight into how computers learn and become familiar with ideas like algorithms by instructing a robot to solve pathfinding puzzles, the training and testing stage, as well as spotting trends in the data.	https://wonderville.org/asset/ViPER
AI for Good from Minecraft Hour of Code	A coding interface is integrated into the game using Minecraft. Players are exposed to fundamental coding ideas and gain knowledge about AI and its potential for environmental protection by creating a robot to forecast forest fires. Additionally, educators are given a lesson plan and accompanying materials (free).	https://education.minecraft.net/hour-of-code
The Moral Engine	When faced with an approaching vehicle collision, the players are challenged to select the lesser of two evils. This website focuses mostly on the area of moral judgment. In light of a moral conundrum, it seeks to address the variety of human viewpoints and the consequences of artificial intelligence that is programmed to reach comparable moral conclusions (e.g., self-driving cars; free).	http://moralmachine.mit.edu/
PopBots (Preschool- Oriented Programming Platform)	The platform's apps are aimed at introducing young children to the fundamental ideas and procedures programming is an example of AI categorization, Using datasets for testing and training straightforward exercises like developing models to distinguish between nutritious and harmful foods or various musical genres. It also contains teaching resources (such lesson plans) for instructors (for more details and related study, see also Williams et al., 2019a; 2019b).	https://www.media.mit.edu/projects/pop-kit/overview/
Universal Paperclips	It's more of a discussion starter than a game to get people talking about the possibilities and role of AI in society. The user assumes the role of an AI computer that manufactures paperclips in this clicker game, which is based on the conceptual thinking experiment "paperclip maximizer" regarding AI design and machine ethics. The game concludes after 100% of the world has been explored and all matter has been reduced to paperclips, with various improvements including the ability to "read and understand human language" or purchase "autonomous airborne brand ambassadors" (web version free).	https://www.decisionproblem.com/paperclips/
Gladiabots: AI battleground	A game that doesn't directly seek to teach kids AI, rather, as the creators put it, players must put together the "ideal squad of robots and determine their AI strategy with the simple to use yet satisfyingly sophisticated visual AI editor." The rationale and framework of AI programming are explained to players (purchase required).	https://gladiabots.com/
Tynker: Kid-Friendly Coding	Platform for kids as young as five that offers games and apps organized by age groupings. By using block programming, kids may make games and publish them (subscription required).	https://www.tynker.com/
Scratch Jr.	targeting kids between the ages of 5-7, the younger version of Scratch. Kids write Coding,	https://www.scratchjr.org/

	programming, and distributing one's own works to the public using a straightforward, visual drag-and-drop interface (for iOS and Android smartphones, without cost).	
Code.org	The website is made specifically for instructors and students, offers a curriculum and lesson plans for computer science education in addition to For learning to code, putting forward fresh initiatives and distributing them to the neighborhood, there are programs, games, and educational courses available. Additionally, Code.org coordinates the yearly Hour of Code initiative, which encourages kids all across the world to learn how to code (free).	https://code.org/
LightBot	A coding-based puzzle game called LightBot teaches programming concepts to kids as young as 4 and up. It has been translated into other tongues. versions for the web (free), iOS, and Android smartphones (with a payment).	
Codespark Academy	A website including games, puzzles, coding tutorials, tools for developing new games, information for parents and teachers, and other content geared toward kids between the ages of 5 and 9 (subscription required).	https://codespark.com/

Table 1 lists the platforms for the games that assist schooling in AI/ML prior to college. plenty of these have applications in teaching CS in its broadest sense as well as teaching AI and machine learning. Particularly, there aren't many games, apps, or platforms that are intentionally designed to promote young people's education in AI and machine learning. The majority of the environments now in use appear to be primarily focused on coding. While games not intended for formal child education focus more on abstract, ethical, and social issues, environments aimed at enhancing Pre-college instruction in AI and ML primarily consider ideas like constructing a model for voice, text, or picture recognition and logical programming (A good example is Minecraft Hour of Code: AI) (e.g., The Moral Machine, Universal Paperclips).

We discovered that the age groups such environments target span from kindergarten through high school (K–12), with some of them focused on even younger ages (appropriate for 4 years old). There are also settings that assist parents and educators in instructing kids on ML and AI (Lesson ideas like Minecraft Hour of Code: AI for Good are an illustration). The majority have been used to implement the materials largely in English, however there are surroundings and materials that support other languages as well (a good example is Code.org).

We observed a wide range of platforms being used from the contexts indicated, including appropriate programs, web-based apps, and applications created for mobile devices such smartphones and tablets. As with any application, those that need to be installed (such While True, Human Resource Machine and Learn()) are more trustworthy more flexible than those that operate totally online without installation and don't necessary need an internet connection (e.g., The Moral Machine). Cost is another crucial aspect of AI/ML learning settings. When we look at The majority of the selected settings, including places like The Moral Machine and Code.org, are free or offer a free version; But a good number of games also call either a purchase or a monthly membership In most situations, the instructor or parent can play the game for free during the trial period (examples include Gladiabots: AI battle arena and Codespark Academy).

the instructors, parents, and pupils at the pre-college level Interpersonal skills are required practically with AI and ML in order to comprehend their core concepts. The majority of the games that were identified have only recently begun to be used by schools and teachers; the majority were produced in recent years. We anticipate both more environments becoming accessible as well as continued development of the ones that are already available. Additionally, in addition to gaming, we have seen an increase in the number of everyday products and utilities (such as the Cortana virtual assistant from Microsoft, Apple, and Google Assistant), moreover, a variety of household gadgets have comparable capability

(Google Home, Amazon Echo, Apple HomePod). The majority utilized among them by younger users and will acquaint using AI technology to them. A step forward further, a number of fresh software and hardware solutions are giving young programmers access to AI components so they can use them in their own works.

AI and ML aren't being adequately addressed in classrooms, despite their growing importance in daily life and society. Think in terms of computation, algorithms, and the teaching of CS in general, nowadays might be revolutionized by opportunities to teach pertinent skills and competences through creative techniques. Students will gain the ability to approach current systems with a more critical and observant eye (for instance, identifying prejudice, false information, unfair search results, and filter bubbles) as well as to take part in the creation of new ones by acquiring knowledge and abilities related the ability to organize facts and information, solve problems, and reason abstractly are all relevant to AI and ML.

There are a lot of games that we found, including apps in this literature research, despite the fact that it seems like Playable AI and machine learning games are still in their infancy that provide either more open-ended environments or guided environments for experimentation with the goal of teaching young children the fundamentals of AI and ML where kids may design their own things and express themselves creatively. Despite the fact that there aren't many places created specifically to introduce young children to the ideas of AI, ML, and related fields, the number is steadily increasing according to a demand from the people. Despite the fact that: PopBots, and Minecraft Hour of Code: AI for Good and others are a few examples of settings with an AI and machine learning emphasis (), PopBots, A few examples of machine learning for children include tools for machine learning and artificial intelligence in education, and other examples of such tools.

The literature has noted both guided and unstructured situations. Both can be utilized to scaffold AI and ML ideas and support various learning designs. For example, While open-ended settings provide students the flexibility to explore, guided environments may help students by providing them with guidance on how to grasp certain ideas, methods, and approaches By engaging in active learning activities and even producing artifacts, students may apply and further their grasp of AI and ML principles.

Supporting materials are a very helpful tool for teachers and students that can help them achieve their learning goals. Because However, pre-college education in AI and ML is still very rare newest subject it takes more than a simple instructional game to introduce, explain, and facilitate a discussion of the pertinent ideas. Playing a game to learn about a subject can be difficult for both the student and the teacher. It also doesn't provide enough depth for conceptual understanding, which could cause misconceptions in the pupils. Environments like Using AI and machine learning in Minecraft: Hour of Code Through the provision of lesson plans, extracurricular activities, and other resources to teachers, education tools encourage excellent practices. This paradigm is used by Camilleri et al. The Malta Ministry for Education supported the publication of a practical guidebook containing curricular materials and teaching aids desiring to instruct pupils on artificial intelligence. It is essential that the learning environments and resources in video games support AI and ML comprehensively for both students and teachers.

Other important aspects that affect the efficiency, adoption, and effects of these learning environments include cost, accessibility, and technology needs. Some residences and pre-college educational facilities are neither technologically or financially equipped to employ the most recent platforms or video games. A range of context-related factors, such as student game literacy and teacher technology expertise, affect the success of a game-based curriculum in the classroom, scheduling restrictions, available bandwidth, and the technical specs of the devices on hand. games that need little in the way of technology and technical prowess, It would appear that formal classroom settings would be better suited for websites like Code.org and They don't require installation, student accounts, or advanced technologies, examples include Hour of Code: AI for Good in Minecraft.

This exploratory work should not be considered a comprehensive review, but rather a first attempt to offer a broad overview and motivate teachers and future scholars. Although we made an effort to locate almost all relevant projects and games, we acknowledge various search techniques, including selections (such as databases and queries) might produce extra fruitful findings. Another potential restriction can come from the projects and games that are

chosen. However, the emphasis of the chosen projects and games was unmistakably on the teaching of AI and ML; two researchers completed the overview and listed the key features. There is a lack of data regarding the effectiveness and student acceptability of many of the reported games because they haven't been utilized and assessed extensively (unlike games published in scholarly journals). This is primarily due to the inclusion of K-12 use of AI and ML schools is still a very new area of study, and we anticipate seeing more initiatives and in the near future, empirical investigations addressing these issues.

5. CONCLUSION

A fascinating area that touches on a variety of AI and ML-related topics that is just beginning to mature is the general game playing industry. We attempted to demonstrate the different features Using video games for AI/ML instruction in high school in this chapter, as well as to highlight the fact that they offer a wealth of engaging and difficult characteristics of professors that wish to formally explain the ideas of AI and ML to their pupils and students in pre-college. We also demonstrated how various games offer a special chance to teach a range of various AI and ML concepts and themes.

Even though there hasn't been much research on using games or additional software to teach Teaching children and teenagers about AI and ML, early findings indicate that this approach has a lot of promise for teaching even preschool children the fundamentals of AI and ML and for getting them talking regarding the significance and effects of technology and artificial intelligence in our daily lives. However, game design for involving kids and ensuring idea understanding can be difficult, needing proper metaphors and simple to comprehend behaviors. Children frequently interact with AI-enhanced software and hardware, including smart homes toys apps, and platforms for broadcasting and sharing video, all of which pose dangers to their privacy, safety, and impartiality. Children can create a more realistic mental representation of the capabilities and limitations of AI/ML by understanding the procedures and elements involved in their design.

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